

Measurement and Control of Oxygen Partial Pressure in an Electrostatic Levitator

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Recently the NASA Marshall Space Flight Center electrostatic levitation (ESL) laboratory has been upgraded to include an oxygen control system. This system allows the oxygen partial pressure within the vacuum chamber to be measured and controlled, at elevated temperatures, theoretically in the range from 10^{-36} to 10^0 bar.

The role of active surface agents in liquid metals is fairly well known; however, published surface tension data typically has large scatter, which has been hypothesized to be caused by the presence of oxygen. The surface tension of metals is affected by even a small amount of adsorption of oxygen. It has even been shown that oxygen partial pressures may need to be as low as 10^{-24} bar to avoid oxidation.

While electrostatic levitation is done under high vacuum, oxide films or dissolved oxygen may have significant effects on materials properties, such as surface tension and viscosity. Therefore, the ability to measure and control the oxygen partial pressure within the chamber is highly desirable.

The oxygen control system installed at MSFC contains a potentiometric sensor, which measures the oxygen partial pressure, and an oxygen ion pump. In the pump, a pulse-width modulated electric current is applied to yttrium-stabilized zirconia, resulting in oxygen transfer into or out of the system. Also part of the system is a control unit, which consists of temperature controllers for the sensor and pump, PID-based current loop for the ion pump, and a control algorithm.

This system can be used to study the effects of oxygen on the thermophysical properties of metals, ceramics, glasses, and alloys. It can also be used to provide more accurate measurements by processing the samples at very low oxygen partial pressures.

The oxygen control system will be explained in more detail and an overview of its use and limitations in an electrostatic levitator will be described. Some preliminary measurements have been made, and the results to date will be provided.